NASA-CR-202438

NASA GRANT NCC2-5071

DEVELOPMENT OF A DETONATION DRIVER FOR THE NASA-AMES HYPERSONIC SHOCK TUNNEL FACILITY

Final Report submitted to the
NASA Ames Research Center
Moffett Field, CA 94035

Funding Dates: July 1, 1994 to June 30, 1995

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October 1996

1. Summary

Research was performed on the 1.5-inch pilot shock tube project. The research was performed by graduate student George Pappas at the Reacting Flow Environments Branch at NASA Ames under the supervision of Dr. Steve Diewert and Professor Brian Cantwell. The main effort involved the design and establishment of a 1.5-Inch High Pressure Shock Tube Pilot Facility. The work focused on the design of an electrical combustion ignition system and shock tube structural mounts.

2. Literature Review

A literature review of methods for initiating either deflagration or detonation combustion in high pressure hydrogen-oxygen-diluent mixtures was performed. Electrical ignition methods such as heated and exploding wires and spark gap electrodes were carefully evaluated. One ignition system was designed to initiate smooth-burn deflagration combustion as is used in the driver section of the NASA Ames 16-Inch Shock Tunnel Facility. The combustion ignition and operating conditions of the 16-inch shock tunnel were evaluated as part of the smooth-burn system design. In addition, a separate detonation initiation system was designed to produce high pressure, shock wave-induced combustion.

3. Combustion Initiation System Design

The ignition system designs were the result of extensive analysis of previous experimental and operational data as well as a theoretical evaluation. Both smooth-burn and detonation initiation systems were designed to discharge large amounts of capacitor-stored electrical energy through tungsten wires. Scaling laws were used to determine the required ignition energy, electrical discharge times, and flame path distances for a variety of combustion driver tube lengths. The smooth-burn ignition system was designed to allow for a parametric variation of ignition energy, capacitance, and voltage.

The capacitor charging and firing circuits of the electrical ignition systems were designed and cost estimates were obtained. An analysis of the capacitor charging circuit was completed in order to determine the power supply requirements. The firing or rapid discharge of the electrical energy through the tungsten wire was studied to assess the impact of inductance and capacitance effects, and variable resistance on system performance.

4. Design of Shock Tube Mounting System

Structural supports were designed to mount the segments of the 20 ft long high pressure shock tube to an existing steel rail. The inner and outer diameter of the high-strength steel shock tubing was 1.5 and 4 inches, respectively. A set of tube mounts was designed to support the shock tube at a height of 16 inches above the grooved rail. The mounts were designed to allow for the exact alignment of the tube segments and the capability for fine adjustments in the height and lateral position of the tubes. In addition, the supports allowed for tube movement in the direction of the tube axis, while providing lateral stability. Simple structural analysis was performed, an evaluation of candidate materials was made, and design sketches were made using AUTOCAD software. Low cost and adaptability to exisiting structures and equipment was a primaryconsideration in the design of the supports.

5. Additional Project-Related Work

Additional work on the project included a significant effort associated with evaluating the facility and building requirements, and upgrading the Pressurized Ballistic Range Building (N-209) to accomodate the shock tube facility. Inspection and cleaning of the shock tubes, which were formerly used in ramaccelerator shock-induced combustion studies, and was also performed. Peripheral equipment and instrumentation, such as high pressure air-actuated valves, was tested and repaired.